

# Unclassified Radiologic Source Term for Nevada Test Site Areas 19 and 20

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**Unclassified Radiologic Source Term for Nevada Test Site Areas 19 and 20**

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## Introduction

The radiologic source term for underground nuclear tests conducted in Areas 19 and 20 of the Nevada Test Site consists of all residual radioactivity including tritium, fission products, activation products, unburned nuclear fuels, and actinides produced by neutron capture. In the context of a dose assessment, the radiologic source term represents the total radionuclide inventory potentially accessible to the environment. An accurate assessment of the radiologic source term is necessary in order to quantify radionuclides with sufficiently long half-lives to be transported to downgradient receptors, determine the proportion of volatile and mobile radionuclide relative to refractory and immobile radionuclides, and evaluate the toxicity of the source term.

## Underground Nuclear Tests Conducted on Pahute Mesa

Figure 1 is a histogram plotting the annual frequency of 76 underground nuclear tests conducted between 1965 and 1992 in Areas 19 and Area 20 of the Nevada Test Site. The histogram includes all events that were fired below or within 100 meters of the water table. These events comprise the radiologic source term for Pahute Mesa. The mean firing date of the tests conducted on Pahute Mesa is April, 1979.

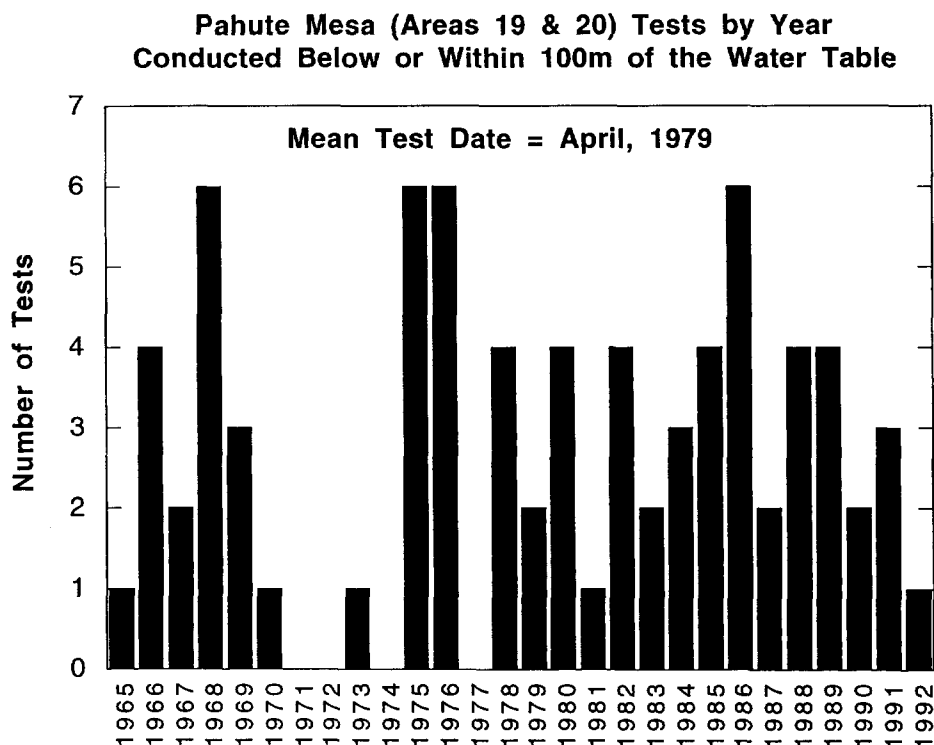


Figure 1

Unlike many other sites with radioactive contamination, the radiologic source term from underground nuclear tests conducted at Nevada Test Site has been accurately quantified. However, by its nature, the source term is also diagnostic of nuclear weapons performance and design. Because the production of radionuclides depends on

the performance of the device, which is in turn indicative of nuclear weapons design, the radionuclide inventory for a single test is always classified. For groups of tests where individual test data is combined, inventory totals can be summed by testing areas.

### **The Unclassified Radionuclide Inventory for Pahute Mesa**

In June, 1994, the Department of Energy issued classification bulletin WNP-87 which provides current classification policy regarding public release of source term data for underground nuclear tests conducted at the Nevada Test Site (DOE, 1994; DOE, 2000). Current guidance permits unlimited distribution of the sum of estimated fission yields, activities of tritium, activities of unfissioned fissile materials by isotope, fission products by isotope with a half-life in excess of one year, and neutron-activated radionuclides by isotope with a half-life in excess of one year for tests conducted below or within 100 meter of the water table on Pahute Mesa. The classification guidance for Pahute Mesa applies to all tests conducted there through 1992. The effective reporting date of the inventory summed by isotope is January 1, 1994.

Using data derived from the nuclear testing program, a radionuclide inventory for each of the 828 underground nuclear tests conducted at the Nevada Test Site was produced by Lawrence Livermore National Laboratory and Los Alamos National Laboratory. A description of the methods used for selecting radionuclides for the inventory as well as the methodology for estimating post-shot radionuclide content is provided by Wild et al. (1998). All water levels and device depth of burials (corrected to as-built configuration) used in organizing the inventory were obtained from nuclear test program data archives.

Table I provides totals for 47 radionuclides summed by isotope for 76 tests conducted below or within 100 meters of the water table in Areas 19 and 20. All radionuclides are reported in moles and curies, decay corrected to January 1, 1994. Table II reports the Table I moles and curies for each radionuclide divided by 76 and represents a mean value for these tests. Half-lives were obtained from the GE Chart of Nuclides, Fourteenth Edition (Walker et al., 1989).

### **References**

- U.S. Department of Energy, 1994, Classification Bulletin – WNP-87, Washington, DC, 2p.
- U.S. Department of Energy, 2000, Restricted Data Declassification Decisions 1946 to the Present (RDD-6), Office of Nuclear and National Security Information, Washington, DC, 130p., with appendices, <http://www.osti.gov/opennet/rdd-6.pdf>.
- Walker, F.W., J.R. Parrington, and F. Feiner, 1989, Nuclides and Isotopes, Fourteenth Edition – Chart of the Nuclides, GE Nuclear Energy, General Electric Company, Nuclear Energy Operations, San Jose, California
- Wild, J.F., Goishi, W., Meadows, J.W., Namboodiri, M. N., and Smith, D.K., 1998, in Atmospheric Nuclear Tests – Environmental and Human Consequences, C.S. Shapiro (ed.), Berlin, Springer – Verlag in Cooperation with NATO Scientific Affairs Division, p. 69 – 77.

Table I

Summed Unclassified Radionuclide Inventory for 76 Nuclear Tests Detonated Below or Within 100m of the Water Table in Areas 19 and 20\*

Reported in Curies; Decay Corrected to January 1, 1994

Radionuclide	Half-Life (years)	Sum (Ci)	Moles
3H	12.3	6.99E+7	2.40E+03
14C	5730	5.55E+2	8.89E+00
26Al	7.3E+5	8.94E-3	1.82E-02
36Cl	3.01E+5	2.14E+2	1.80E+02
39Ar	269	1.85E+3	1.39E+00
40K	1.28E+9	4.69E+2	1.68E+06
41Ca	1.03E+5	1.64E+3	4.72E+02
59Ni	7.6E+4	3.99E+1	8.48E+00
63Ni	100	4.21E+3	1.18E+00
85Kr	10.73	9.54E+4	2.86E+00
90Sr	29.1	1.19E+6	9.68E+01
93Zr	1.5E+6	4.17E+1	1.75E+02
93Nb	16.1	7.59E+3	3.42E-01
94Nb	2.0E+4	1.73E+2	9.67E+00
99Tc	2.13E+5	3.07E+2	1.83E+02
107Pd	6.5E+6	1.57E+0	2.85E+01
113Cd	14.1	1.16E+3	4.57E-02
121Sn	~55	4.31E+3	6.63E-01
126Sn	~1E+5	4.92E+1	1.38E+01
129I	1.57E+7	9.45E-1	4.15E+01
135Cs	2.3E+6	3.17E+1	2.04E+02
137Cs	30.17	1.51E+6	1.27E+02
151Sm	90	5.71E+4	1.44E+01
150Eu	36	1.11E+3	1.12E-01
152Eu	13.48	3.29E+4	1.24E+00
154Eu	8.59	1.55E+4	3.72E-01
166Ho	1.2E+3	4.48E+1	1.50E-01
232Th (device)	1.4E+10	5.84E-2	2.29E+03
232Th (soil)	1.4E+10	3.38E+1	1.32E+06
232U	70	2.55E+2	4.99E-02
233U	1.592E+5	1.71E+2	7.61E+01
234U (device)	2.46E+5	1.23E+2	8.46E+01
234U (soil)	2.46E+5	1.67E+1	1.15E+01
235U (device)	7.04E+8	1.66E+0	3.27E+03
235U (soil)	7.04E+8	7.94E-1	1.56E+03
236U	2.342E+7	4.73E+0	3.10E+02
238U (device)	4.47E+9	2.19E+0	2.74E+04
238U (soil)	4.47E+9	1.67E+1	2.09E+05
237Np	2.14E+6	3.65E+1	2.18E+02
238Pu	87.7	7.16E+3	1.76E+00
239Pu	2.41E+4	1.93E+4	1.30E+03
240Pu	6.56E+3	6.20E+3	1.14E+02
241Pu	14.4	9.00E+4	3.62E+00
242Pu	3.75E+5	3.36E+0	3.52E+00
241Am	432.7	4.67E+3	5.65E+00
243Am	7.37E+3	1.79E-1	3.69E-03
244Cm	18.1	2.97E+3	1.50E-01

\*<sup>150</sup>Gd was not included in the original radiologic source term for Areas 19 and 20 but was considered important due to its decay properties; the summed inventory for <sup>150</sup>Gd is 3.81E-7 Ci and 1.92E-6 moles.

**Table II**

Mean Unclassified Radionuclide Inventory for 76 Nuclear Tests Detonated Below or Within 100m of the Water Table in Areas 19 and 20\*\*

Reported in Curies; Decay Corrected to January 1, 1994

Radionuclide	Half-Life (years)	Mean (Ci)	Moles
3H	12.3	9.20E+05	3.16E+01
14C	5730	7.30E+00	1.17E-01
26Al	7.3E+5	1.18E-04	2.41E-04
36Cl	3.01E+5	2.82E+00	2.37E+00
39Ar	269	2.43E+01	1.83E-02
40K	1.28E+9	6.17E+00	2.21E+04
41Ca	1.03E+5	2.16E+01	6.22E+00
59Ni	7.6E+4	5.25E-01	1.12E-01
63Ni	100	5.54E+01	1.55E-02
85Kr	10.73	1.26E+03	3.78E-02
90Sr	29.1	1.57E+04	1.28E+00
93Zr	1.5E+6	5.49E-01	2.30E+00
93Nb	16.1	9.99E+01	4.50E-03
94Nb	2.0E+4	2.28E+00	1.27E-01
99Tc	2.13E+5	4.04E+00	2.41E+00
107Pd	6.5E+6	2.07E-02	3.76E-01
113Cd	14.1	1.53E+01	6.03E-04
121Sn	~55	5.67E+01	8.72E-03
126Sn	~1E+5	6.47E-01	1.81E-01
129I	1.57E+7	1.24E-02	5.44E-01
135Cs	2.3E+6	4.17E-01	2.68E+00
137Cs	30.17	1.99E+04	1.68E+00
151Sm	90	7.51E+02	1.89E-01
150Eu	36	1.46E+01	1.47E-03
152Eu	13.48	4.33E+02	1.63E-02
154Eu	8.59	2.04E+02	4.90E-03
166Ho	1.2E+3	5.89E-01	1.98E-03
232Th (device)	1.4E+10	7.68E-04	3.01E+01
232Th (soil)	1.4E+10	4.45E-01	1.74E+04
232U	70	3.36E+00	6.57E-04
233U	1.592E+5	2.25E+00	1.00E+00
234U (device)	2.46E+5	1.62E+00	1.11E+00
234U (soil)	2.46E+5	2.20E-01	1.51E-01
235U (device)	7.04E+8	2.18E-02	4.29E+01
235U (soil)	7.04E+8	1.04E-02	2.05E+01
236U	2.342E+7	6.22E-02	4.07E+00
238U (device)	4.47E+9	2.88E-02	3.60E+02
238U (soil)	4.47E+9	2.20E-01	2.75E+03
237Np	2.14E+6	4.80E-01	2.87E+00
238Pu	87.7	9.42E+01	2.31E-02
239Pu	2.41E+4	2.54E+02	1.71E+01
240Pu	6.56E+3	8.16E+01	1.50E+00
241Pu	14.4	1.18E+03	4.75E-02
242Pu	3.75E+5	4.42E-02	4.63E-02
241Am	432.7	6.14E+01	7.43E-02
243Am	7.37E+3	2.36E-03	4.86E-05
244Cm	18.1	3.91E+01	1.98E-03

\*\*<sup>150</sup>Gd was not included in the original radiologic source term for Areas 19 and 20 but was considered important due to its decay properties; the mean inventory for <sup>150</sup>Gd is 5.01E-9 Ci and 2.52E-8 moles.